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(71) Applicant: Essex Invention S.A.
Via General Nicanor A. de Obarrio
Panama City (PA)

(72) Inventor: Scarlatti, Francesco
Corso Firenze 9
Genova (IT)

(74) Representative: Baggiolini, Raimondo Patent Attorneys et al
Flammenghi-Flammenghi
Via San Gottardo 15
CH-6900 Lugano (CH)

(54) A contactor, particularly a vapour exchanger for the control of the air hygrometric content, a device for air handling.

(57) A contactor, particularly a vapour exchanger, working by means of the sorption or desorption of water vapour from or into an air stream (U) by an aqueous hygroscopic solution inside the contactor which is formed by at least a container (1) with wall/walls (101) in contact with the air stream (U) whose air vapour content is to be controlled. The walls (101) of the container (1) in contact with the air stream (U) are provided by many capillary open micropores such as to be impermeable to the solution but sufficiently permeable to the water vapour transfer to/from the solution.

A device for handling air, particularly for dehumidification and/or humidification and air conditioning has at least a contactor (1) in combination with means (6, 6') adjusting the temperatures of the hygroscopic solution and/or of the air streams for controlling the transfer sense and rates of the vapour.

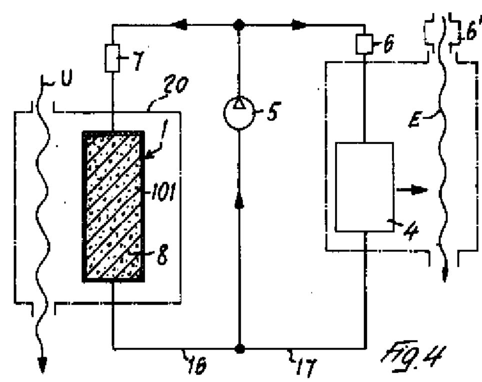

Fig.4

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The present invention regards a contactor particularly vapour exchanger, to control the air hygrometric content in dehumidification, humidification and air conditioning equipments, on the basis of sorption or desorption phenomena of water vapour taking place with water or with hygroscopic solution from or into an air stream coming from a conditioned enviroment and/or from or into the indoor air of the enviroment itself.

In the known air handling mass exchangers which make use of hygroscopic solutions these ones are brought into direct contact with the air either by percolating and/or spraying the liquid phase in form of drops/droplets through the air stream or by air bubbling through a filled-type column. In both cases the air stream is in direct contact with the liquid phase and water vapour exchanges take place between the said phases.

According to the specific application involved, the air stream, usually dehumified by these devices, is then, further thermodinamically handled before being sent, for instance, into the conditioned enviroment.

These well known direct contact mass exchangers present some inconvenients such as:

- absorption process limited by the air- liquid dessicant contact area. If the contact area is increased by spraying onto extended surfaces the solution, problem arise when a high viscosity solution has to be used.
- contact area dependent of both the air and solution flow rate.
- air particulates and dust may progressively dirty the hygroscopic solution;
- dehumidification or humidification devices have large dimensions and their maintenance and servicing is not easy;
- high friction loss along the air path in the case of a filled-type column.

In all cases it is necessary to put into service high efficency filters in order to avoid carryover of solution's droplets in the handled air stream which often may cause ducts corrosion phenomena.

An object of the invention is to provide a contactor, particularly for air handling i. e. exchanging water vapour, of the kind described at the beginning which avoids all the above mentioned troubles while presenting, at the same time, a relatively simple and cheap assembling, sufficiently high mass transfer rates, a simple, sure and handy utilisation and a good manufacturing adaptability to various fields of employment.

The invention achieves the above mentioned goals with a contactor, particularly for exchanging water vapour, consisting, at least of a container having border wall or walls in direct contact with an air stream in which the vapour content is to be controlled, a hygroscopic solution being set or flowing inside the container which is sealed at all its sides and the container's walls being provided with many capillary open pores such as to be impermeable to the solution till to a determined maximum inside pressure of the liquid phase, but sufficently permeable to the water vapour transfer to/from the solution.

The border walls between the air to be handled and the hygroscopic solution are formed by a hydrophobic material which may be in the form of a membrane.

Suitable microporous membranes may be made up by a thin polytetrafluoroethylene (PTFG), by a thin cristalline poly-ethylene microfibre material tightly heat sealed to one another, or by similar hydrophobic microporous film while the container may assume easily any desired shape and be assembled, by heat sealing or gluing with suitable adhesives at their peripheral edges one or more properly shaped, bended or unbendend membrane pieces.

Such walls with their open micropores avoid a direct contact between the moist air and the hygroscopic solution without penalising too much the mass transport rates between these phases. The resistance to the mass transport due to the interposition of such a membrane separating said phases is widely compensated by the easier assembling of the mass exchanger, by its reduced manufacturing costs, by its reliabler, simpler and handier use. The routine maintenance of contactors is limited. The contactor is suitable for different applications since extended surfaces variable at will for the mass exchange may be easily obtained, for instance by adopting a compact modular construction.

In respect of the traditional direct contact approach the contactors according to the invention present in air handling advantages such as:

- low friction loss along the air path;
- elimination of carryover effects;
- a contact area between the phases which is independent from both the solution and the air flow rate;
- prevetion of any pollution of the hygroscopic solution by dust and particulate carried by the air;
- mass exchange surfaces handily and easily variable according to need;
- a fairly good compactness with a hugh "area density" i. e. high ratio mass transfer surface to volume;
- particularly using hygroscopic solutions like LiCl absence of hygenical problems upon the membrane surfaces facing air, due to the bactericide and bacteriostatic activity of LiCl preventing any micro-organism to grow.

Such contactors can be adopted without significant modifications to replace the direct contact vapour exchangers working with liquid adsorption in some known installations already in use in civil and industrial air dehumidification and conditioning.

Semipermeable membranes allow to give easily different and quite complex shapes to mass exchangers. The membranes can be preformed during their manifacture process; alternatively the membranes can be manufactured, for instance, in form of tubular/planes elements, allowing also a handy assembling of differently shaped containers of the mass exchanger.

Should conditions be convenient for the use of liquid adsorption processes, for instance when thermal energy at relative low temperature is available to regenerate the hygroscopic solution, this innovative vapour exchanger, reducing or eliminating at all some problems typically associated with direct contact air handling processes with hygroscopic solutions (dehumidification and conditioning) and presenting the above mentioned advantages, facilitates a more extended use of liquid adsorption process even when it is still popular to adopt the traditional cooling process though it requires more power consumption.

By taking advantage of these contactors a more extended use of combined systems where both adsorption and cooling operate toghether may be also forseen for selected applications in which thermal energy at relative low temperature is available since in this case cooling power savings up to 50% are possible; for instance for transport vehicles, small cars air conditioning etc.. .

Furthermore, also in absence of any thermal energy sources, such combined systems may allow significant savings (up to 40-50%) of either cooling or electric power in air handling processes if, to regenerate the hygroscopic solution, the thermal energy rejected at the condenser of the cooling unit at temperatures about 40-50 °C could be used. These important goals might be achievable by means of an extended area membrane contactor provided with a very thin and very permeable membrane.

Any savings of cooling power required to handle air may present a great interest in order to reduce the negative impact on the natural ambient of the C.F.C. (freon fluids) already used in the cooling cycles. As known the use of such fluids is restricted under international agreements, so that new fluids and new technologies are in the way to be studied the world over.

The invention regards also an air handling device, particularly for dehumidification/humidification, having a principal circuit for the hygroscopic solution (dehumidification/humidification circuit) in which at least a contactor according to the invention is provided for water vapour transfer from the air of the conditioned enviroment to be handled to the hygroscopic solution circulating through the contactor or the reverse and a second parallel circuit (regeneration circuit) in which a regenerator of the hygroscopic solution is provided for exchanging water vapour from at least part of the hygroscopic solution into the air of the outside enviroment or reverse, means being provided for heating or cooling at least the hygroscopic solution circulating in the regeneration circuit and/or the air of the outside enviroment coming in contact with the regenerator till to suitable working temperatures allowing the vapour disposal from the hygroscopic solution into the external air crossing the regenerator or the reverse.

According to a further improvement in combination with the heating or cooling means of the hygroscopic solution in the regeneration circuit and/or of the external air coming in contact with the regenerator, in the principal circuit further means for adjusting the temperature and/or the composition of the hygroscopic solution in relation to the status of the air of the conditioned enviroment can be provided

Advantageously also the regenerator is formed by a contactor according to the invention.

A further improvement of the invention regards a device for hygrometric stabilisation of segregated premises or cases, particularly of low volumetry, such as museum showcases, electronic controlling units cases, or similar ones, having a humidification/dehumidification circuit with at least a contactor according to the invention working between the air of the segregated enviroment or an air stream coming from said segregated enviroment and a hygroscopic substance inside the contactor, a parallel regeneration circuit for the hygroscopic solution with at least a regenerator, i.e. a contactor working between the hygroscopic solution and the air of the outside enviroment, means for heating or cooling at least part of the total mass of the hygroscopic solution, i. e the hygroscopic solution circulating through the regenerator and/or the air of the outside enviroment contacting the regenerator, which cooling and heating means are driven by controlling means working in relation with the hygroscopic solution concentration variation occurred with respect of a prefixed value and which is read by suitable sensors.

The hygroscopic solution may be an acqueous solution of suitable organic substances, for instance glycerol, tryethyleneglycol or salt solutions such as $LiCl$, $MgCl_2$, $Ca(NO_3)_2$, or a mixture of these ones of suitable composition.

It is possible to observe that the use of a hygroscopic solution may also allow an adsorption and/or chemical neutralisation of some chemical

substances often present in the air in areas with sensible air pollution; for instance, it is possible to dissolve into the hygroscopic solution traces of compounds able to neutralise the polluting substances, such as $NaHCO_3$ to neutralise NO_2.

The inventions regards also other characteristics which improve further the mass exchanger and the devices described above and that are matter of the dependent claims.

The invention's characteristics shall be pointed out in a more extended way in the following description of non restrictive embodiments which are shown in the enclosed drawings in which:

Figure 1 shows a perspective view of an embodiment of the contactor according to the invention.

Figure 2 and figure 3 show a further embodiment of the mass exchanger according to the invention.

Figure 4 show diagrammatically a device for air handling, particularly for dehumidification, employing a contactor according to the preceding figures.

Figure 5 shows a device for automatically controlling and stabilising the air relative humidity in a segregated enviroment of low volumetry, as for example museum showcases or similar ones applying contactors according to the invention.

The contactor shown in fig. 1, which is particularly suitable to control the relative air humidity inside small cases or premises, consists of a relatively small container 1 for the solution that may be manufactured like a sealed envelope.

The envelope is made by a thin porous membrane 101 with a highly hydrophobic behaviour as regards to the liquid phase and having a plurality of open microcapillaries of suitable size in order to be watertight to the hygroscopic solution contained in it (at least till to a prefixed level of the inside liquid phase pressure), while still allowing suffucently high vapour transport rates to/from the solution itself.

The vapour exchanger may be either used as a simple container which can be placed directly into the cases/premises or into an air handling system as for example the dehumidification system according to figure 4.

In fig. 4, the moist air to be handled U comes into contact with the walls 101 of the container 1, where the dehumidification process takes place. The container 1 (contactor) has pipe connections for the inlet 2 and for the outlet 2 that are fitted to the principal circuit 16 (dehumidification/humidification circuit) in which the hygroscopic solution flows. A pump 5 allows slow circulation of the hygroscopic solution. In parallel to this circuit, another circuit 17 is provided to regenerate the hygroscopic solution. In this last circuit (regeneration circuit) a fraction of the solution flow rate crosses a regenerator (a second vapour exchanger) 4 where the solution is concentrated. The regenerator 4 which may be also of whatsoever kind, is a contactor like the container 1. The container 1 is set into a vane 20 segregated from the enviroment, the air of which has to be handled. A stream U of air to be handled crosses througout the said vane.

A heat exchanger 7 is provided upstream the container 1 to control suitably the working temperature of the hygroscopic solution in the principal dehumidification/humidification circuit. By adjusting both the solution temperature and its working composition in relation to the moist air status and/or adjusting the air stream temperature it is possible to control the hygrometric content of the air at the outlet of the contactor 1. In the regeneration circuit, always referring to the same flow sense, the solution or the external air E or both are suitably heated/cooled by means of heat exchangers 6 and 6' till to suitable working temperatures of these fluids allowing the vapour disposal from the hygroscopic solution into the external air crossing the regenerator 4 or the reverse.

As shown in fig. 5 in relation to a further embodiment of the invention, both the principal dehumidification/humidification circuits and the regeneration circuit may depart from and return to a common plenum container for the hygroscopic solution or to separate plenum and regeneration containers each one associated with one circuit and comunicating one with the other.

In order to distribute the solution flow over the section of the container 1, inside of this one, a suitable porous filling 8 may be provided, for instance, a synthetic felt material or similar components.

Suitable microporous semipermeable membranes may be made up by a thin polytetrafluoroethylene (PTFG), by a thin polyethylene microfibre material stochastically oriented and tightly heat-sealed to one another, or by similar hydrophobic microporous film. Suitable membranes of this kinds are already on sale, for instance by Du Pont de Nemours with the trade-mark Tyvek such as Tyvek L-1056B or by Gore Associated with the trade-mark Gore-Tex.

Such membranes may be easily connected to each other by heat sealing or gluing so that the container (exchanger) 1 may be economically assembled by heat sealing or by gluing with suitable adhesives the border stripe 201 of a membrane piece bended on itself or two or more membrane pieces 101.

Any kind of shape of the container is possible. Figures 3 and 4 show another embodiment of the vapour contactor which is suitable to be adopted for industrial applications, for instance for air dehumidification purpose and/or also for civil air con-

ditioning.

Many containers 1' in form of hollow envelopes manufactured by using a semipermeable membrane similar to the above mentioned ones are connected at each opposite extremity 10, 11 to the feeding and returning pipes by means of common manifolds 12 and 13, forming two opposite sides of a supporting frame 14. The containers 1' are sealed along their vertical edges for instance by heat sealing, by gluing or by suitably clamping the said vertical edges of two membranes 101. The containers 1' are spaced each other in order to let suitable interspaces 15 through which ones the air stream to be handled crosses.

In order to reduce any deformation of the containers, for instance bellying of these ones due to both static or dynamic controbutions to the inside liquid pressure, these containers may be wrapped up by a carrying structure 9 in form of a reticulated holder extending all around them.

As for the preceding example, these containers 1' may be equipped with suitable internal porous filling (not shown).

In a further embodiment (not shown), in place of a plurality of containers 1' the contactor may consist of vapour exchanging modules providing membrane self-supporting tubular elements (diameter ranging from about 1 to 5 mm) in which the hygroscopic solution flows. By means of such tubular elements or also by using other assembling geometries, exchange surfaces per unit volume around 1500-2000 m^2/m^3 may be easily obtained. Values as high as 5000 ÷ 1000 m^2/m^3 can be obtained with lower diameter hollow membrane fiber contactors.

The vapour exchange rates taking place between moist air and a hygroscopic aqueous solution through such a membrane is governed by gradients of the chemical potentials of the water in the two said phases, i.e. by gradients of both partial vapour pressure and temperature. By means of a vapour exchanger, i.e. a contactor similar to the one in fig. 1 an experimental investigation was performed. The container 1 was made by Tyvek L-1056B membrane manufactured by Du Pont de Nemours. The membrane characteristics were: mass per unit area about 55 gr/m^2, thickness 0,17 mm having resistance to water penetration till to pressure difference of about 10000 Pa.

The vapour transfer rates between moist air and a saturated LiCl solution (absorption rates) measured at 21 °C in isothermal conditions (mass transfer only controlled by the water vapour partial pressure difference) were about 0,038 g/(m^2hPa) in still air while with air in forced convection higher values of the order of 0,078-0,084 g/(m^2hPa) were observed, at least for air velocities ranging from 1 to 3 m/s.

In absence of partial pressure gradients, but in no isothermal conditions, the thermal driven vapour flow through such membrane (desorption rates) was also noticeable, for instance a vapour flow rate of about 290 g/(m^2h) was observed from a colder $Ca(NO_3)_2$ (56% in mass) solution at 38 °C to a air stream heated up tp 65 °C, at least for air velocities around 2-3 m/s. The air had a specific humidity of 6.2 g/kg.

Finally in relation to the handled air status the vapour transfer rates throughout such membranes may be then controlled by adjusting suitably the solution composition and/or the temperatures of the two phases. It is also possible, if required, to make use of more diluted solutions or pure water adjusting the phases temperatures to suitably control the sense of the vapour exchanges.

Theoretical simulations have pointed out that very high vapour transfer rates between a hygroscopic solution and a warmer air stream could be reached by adopting thinner and more permeable membranes such as, for instance, a 25-30 microns polytetrafluoroethylene (PTFG) Gore-Tex membrane.
For instance absorption rates of about 1000-1200 gr/(m^2h) and desorption rates up to 7000 gr/(m^2h) can be reached according to the solution temperature. The application of this technology may have a very great development potentially allowing also significant energy and cooling power savings in respect to the traditional cooling process. For instance, air handling combined systems (adsorption + cooling) may be forseen in which to regenerate the solution, the thermal energy rejected at the condenser of the cooling unit at temperatures of about 40-50 °C could be used. In this temperature range the desorption vapour flow of nearly 200-500 gr/(m^2h) can be obtained. These important goals might be achievable by means of a extended area membrane vapour exchanger provided with a very thin and very permeable membrane.

Figure 5 shows a particulary advantageous embodiment of the device according the invention particularly suitable for the automatic hygrometric controll of small volume segregated premises. A segregated enviroment A, particularly of small volume, is set in communication with a contactor 1 in a separate vane 20 by means of ducts 120, 220, allowing the circulation of an air flow U coming from the said enviroment A. The vapour exchange taking place between the hygroscopic solution and the air inside the said enviroment. The air circulation is mantained by means of a small fan 21. The sense of such vapour exchanges may be from the solution to the air or the reverse. Every kind of vapour exchanger having the above mentioned characteristics may be used, for instance a vapour exchangers according to figure 1 or to figures 2

and 3.

The principal circuit 16 comprises the contactor 1 and a first plenum container 22 connected toghether by means of feeding pipe 24 and return pipe 23. The liquid circulation between the plenum container 22 and the contactor 1 is mantained by means of a small pump 5.

At its bottom the plenum container 22 is connected with the bottom of a second smaller regeneration container 26 through a copper coil pipe 25 allowing a fairly good heat exchange with the surrounding ambient, or similar means. In the return 23 or in the feeding 24 pipe respectively from or to the vapour exchangers 1 there is a branch 27 debouching into the regeneration container 26. The branch 27 is supplied by a throttling valve 28 to adjust the solution flow rate in this branch.

The second regeneration container 26 is part of the regeneration circuit 17 and is connected to a regenerator 4 by means of a feeding 30 and return 31 pipe, while another pump 5' allows the liquid circulation throughout the regenartor 4. The regenerator 4 is a second vapour exchanger set outside the segregated enviroment A working to perform vapour exchanges between the hygroscopic solution and the outdoor air E either from the air into the solution or the reverse.

The regenerator 4 may be similar to the above container 1 which is in communication with the segregated enviroment A. In the regeneration container 26 or in the pipe 30 feeding the regenerator 30 there is a heat exchanging element 33, which, for instance, could consist of a coil excavated in a aluminium plate set in a thermal direct contact with one of the two plane bases 134 of a thermoelectric Peltier element 34. The thermoelectric element 34 is fed by a direct current having a suitable polarity which allows either to heat or to cool progressively the hygroscopic solution inside the regeneration container 26 till to suitable working temperatures which allow the concentration or the dilution of the solution as a consequence of the positive or negative vapour exchanges taking place with the surrounding air E. Alternatively or in combination with the heating or cooling of the solution it is also possible to heat or to cool the air in contact with the porous walls of the regeneration container 26 by means of a thermoelectric element similar to the one 34.

Therefore any positive or negative concentration variation occurring inside the regeneration container 26 are going to be replicated into the whole solution mass as a consequence of a prefixed very modest liquid circulation between the said containers which is allowed throughout the adjustable flow branch 27, 28 and by the communication coil 25 at the bottom of the containers 22, 26.

The liquid level in the plenum container 22 is always correlated to the solution concentration since both the liquid levels are going to be always almost equal according to the communicating vessels principle. As a consequence the liquid level inside the plenum container 22 may be monitored in order to start the regeneration process either in a sense or in the reverse one, i. e. in order to start the pump 5' and to feed the Peltier element 34 with an electric direct current with suitable polarity.

Since the positive/negative thermal fluxes exchanged by the solution in the Peltier element may be controlled at will, both in sense (positive/negative) and/or in entity by means of both the polarity and the electric voltage applied, in order to nearly equalise these regeneration thermal exchanges (positive/negative) suitable electric polarity with prefixed different volatges should be fed.

At the bottom of the two containers 22, 26 the communication coil 5' (it may be made as a copper coil of about 5 mm diameter) allow the flowing solution to be nearly in thermal equilibrium with the surrounding enviroment as a consequence of the very modest liquid flow rate which is recirculated from the regeneration container 26 to the plenum one 22.

When the regenerator 4 is crossed by a heated solution or the air contacting this last is heated a vapour flow from the liquid solution to the surrounding air takes place while the reverse happens when the liquid or the air is cooled.

Such negative/positive vapour exchanges bring about respectively, an increased or a decreased concentration of the hygroscopic solution, this last controlling the air relative humidity in the enviroment A.

An electronic unit 35 having a setting point gauged to a prefixed air humidity, i. e. to a solution concentration, is used to select the polarity, to start the pump 5' and to supply the suitable prefixed electric voltage to the Peltier element 34.

The effective value of the hygroscopic solution concentration is read by one or more than one sensor/transductors 37. The sensor/transductors 37 may be of whatsoever kind.

The control unit 35 is provided with means having also the function of reading prefixed reference value of the solution concentration and means for comparing the signal furnished by the sensor 37 with the prefixed one, which means select the polarity and supply the suitable prefixed voltage to the Peltier element 34 until a prefixed difference between the two signal exist, taking into account the observed difference between the said signals.

According to figure 5, it is possible to adopt either a simple liquid level sensor set inside the plenum container 22 or a air relative humidity sensor. In this last case, the plenum container 22 is to

be sealed and the sensor reads the air relative humidity in the air space above the solution or in a suitable air vane in open communication with the said air space.

Also in absence of the said regeneration processes the total solution mass inside the device works as a passive controlling system with a very great moisture buffering capacity which, alone, may be able to damp, at least for a period of time, the air humidity fluctuations inside the enviroment A.

When possible (i.e. in climatic conditions where the annual average relative humidity does not differ from the desired one inside the enviroment A) a fully passive control of the air may be usefully obtained by means of the present device. In this case the regeneration process of the solution may be eliminated from the present device, which could work only by taking advantage of a suitable volumetric capacity of the plenum container 22 connected to the vapour exchanger 1 set inside or in communication with the enviroment A and with the pump 5 allowing the liquid circulation throughout the said components. The total solution mass and so its moisture buffering capacity may be easily varied and adjusted to needs.

Inside the premises/cases repeated air humidity fluctuatins of short period (such as few hours) are particularly dangerous for a suitable conservations of goods such as many historical and cultural works. With the device according to the invention a continously maintenance free working and fully automatic control of the inside relative humidity around a prefixed value into a segregated premise/case is achieved. By mantaining the hygroscopic solution's concentration prefixed and constant, it is possible to control the air relative humidity around the wanted level inside the premise/case. Such device, exchanging water vapour in two senses, from/to the inside air, is then suitable to stabilise the inside air relative humidity damping the climatic fluctuations (temperature and/or vapour content) occuring in the surrounding enviroment. Furthermore also the quantity of hygroscopic solution is held low and the construction of the device is very simple and economic.

The device for the hygrometric control of small volume segregated premises which has been described above is particularly advantageous in combination with contactors of the type according to the invention. Nevertheless, the device for the hygrometric control achieves functional improvements also when, instead of contactors according to the invention for the vapour exchanger working with the air to be handled and/or for the regenerator or for both ones mass exchangers the known traditional type are employed.

Claims

1. A contactor, particularly water vapour exchanger, to control the air hygrometric content working by means of the sorption or desorption of water vapour from or into an air stream by an aqueous hygroscopic solution of suitable composition characterized in that the exchanger is formed by at least a container (1, 1') whose wall/walls (101) is/are brought into contact with the air stream (U), whose air vapour content is to be controlled, the container (1, 1') being sealed at all its sides and the hygroscopic solution being set inside or flowing inside the said container (1, 1'), while the wall/walls (101) of the container (1, 1') in contact with the air to be handled (U) are provided with many capillary open micropores such as to be impermeable to the solution up to a determined inside pressure of the liquid phase, but sufficiently permeable to the water vapour transfer to/from the solution.

2. A contactor according to claim 1, characterized in that the porous wall/walls manufactured by a material with a highly hydrophobic behaviour as regards to the liquid phase.

3. A contactor according to claims 1 or 2, characterized in that the wall/walls of the container (1, 1') are in form of semipermeable membranes (101).

4. A contactor according to claim 3, characterized in that the membrane is formed by a thin polytetrafluoroethylene (PTFG), by a thin cristalline poly-ethylene microfibre material stochastically oriented and tightly heat-sealed to one another, or by similar hydrophobic microporous film.

5. A contactor according to one or more of the preceding claims, characterized in that the container (1, 1') holds inside a suitable porous filling (8), for instance a synthetic felt material or similar components.

6. A contactor according to one or more of the preceding claims, characterized in that the container (1, 1') is wrapped up at least partially by a carrying structure (9) in form of reticulated holder.

7. A contactor according to one or more of the preceding claims characterized in that it has a cross-flow, modular construction comprising a plurality of containers (1') with a predetermined reciprocal disposition one to the other and

spaced one from the other in order to form interspaces (15) for the air flow (U), each container (1') being connected at opposite sides to common feeding and return pipes or mainfold (12, 13) for the solution.

8. A device for the hygrometric control of segregated premises or cases, comprehending a contactor according to one or more of the preceding claims characterized in that the total mass of hygroscopic solution is statically set in the container (1, 1') which is seald all over and has a capacity such that the total hygroscopic solution works as a moisture buffer.

9. A device according to claim 8, characterized in that the container (1, 1') is connected to a principal circuit (16) for a hygroscopic solution connecting toghether an inlet and an outlet pipe (2, 3) or inlet or outlet manifolds (12, 13) of the container (1, 1'), a circulation pump (5, 5') being provided at least in the principal circuit (16).

10. A device according to claim 9, charaterized in that a second regeneration circuit (17) is connected in parallel to the principal circuit (16) and leads at least part of the total mass of the hygroscopic solution to a regenerator (4) consisting in a vapour contactor working between the hygroscopic solution circulating in the regeneration circuit (17) and the outside air (E).

11. A device according to claim 9 or 10, characterized in that at least the regeneration circuit (17) is associated with means (6, 6'; 33, 34, 134) for adjusting alternatively or in combination the temperatures (cooling or heating) of the hygroscopic solution and/or the air streams (E) crossing the regenerator, in relation to the temperature of the outside enviroment, for controlling fully or partially the sense (sorption or desorption of water vapour from or into the outside air (E)) and the transfer rates of the vapour exchange between the hygroscopic solution and the outside air (E).

12. A device according to claim 11, characterized in that in the principal circuit (16) means (7) are provided for adjusting the hygroscopic solution temperature and/or its composition in relation to the status of the air (U) to be handled.

13. A device according to one or more of the preceding claims 9 to 12, characterized in that the principal circuit (dehumidification/humidification circuit) (16) and the regeneration circuit (17) are connected toghether by means of at least a common plenum container.

14. A device according to claim 13, characterized in that each circuit (16, 17) is connected to a separate container, i.e. a plenum and a regeneration container (22, 26), the container being connected toghether (36) at least at their bottom and each circuit having pumps (5, 5').

15. A device for the hygrometric controll of segregated premises or cases (A), particularly of low volumetry, such as musemum showcases or the like, according to one or more of the preceding claims 9 to 14, characterized in that at least one contactor (1) of the principal circuit (16) may be directly set inside the premise/case (A) or inside a vane (20) connected (120, 220, 21) to this one, i. e. in direct contact with an air flow circulating among the premise/case (A) and the vane (20) itself, the hygroscopic solution flowing also throughout, at least a regenerator (4) placed outside the segregated enviroment (A), i. e. a vapour exchanger between the hygroscopic solution and the air (E) outdoor the segregated enviroment (A), means (6', 33, 34, 134, 35) being provided in order to alternatively heat and/or cool, at least part of the whole solution mass or the outside air (E) handled by the regenerator (4) up to suitable working temperatures, the contactor (1) associated to the segregated enviroment (A) and the regenerator (4) handling the external air (E) being suitable to allow vapour exchanges in two senses to or from the air coming in contact with them while the heating and cooling means (6', 33, 34, 134) are driven by controlling means (35) working in relation with the hygroscopic solution concentration variation occured in respect of a prefixed value and which is read by suitable sensors (37).

16. A device according to claim 15, characterized in that the heating and/or cooling means may consist in a thermoelectric Peltier element (34) having one plane base (134) in thermal contact with a suitable heat exchanger (33) crossed or in contact with at least a portion of the whole solution mass which is fed into the regenerator (4) and/or a thermoelectric Peltier element (6') which is crossed or in contact with an external air flow (E).

17. A device according to claim 16, characterized in that the heating and/or cooling means (34, 134) are driven by controlling means (35) working on the basis of the concentration variation occurred in the solution in respect of a

prefixed value read by a suitable sensor (37), while the Peltier element/elements (6', 34) is/are fed by a direct current having suitable polarity which allows either to heat or to cool progressively the hygroscopic solution and/or the external air flow handled by the regenerator (4) up to a suitable working temperature.

18. A device according to claim 17 characterized in having means (35, 37) to perform either positive or negative heat exchanges of the Peltier element (6', 34) of similar entity, i. e. means allowing to feed the Peltier element with an electric direct current having both the correct polarity and the prefixed different voltages to nearly equalise the regeneration positive or negative thermal exchanges.

19. A device according to one or more of the preceding claims 15 to 18, characterized in that the the plenum container (22) associated to the principal circuit (16) and the second regeneration container (26) associated to the regeneration circuit (17) are connected toghether by a communication coil (25) at their bottom and having a branch (27) which has a throttling valve (28) to adjust the liquid flow rate and which departs either from the return pipe (23) or from the feeding pipe (24) of the principal circuit (16) associated to the contactor (1) in serivice to the segregated enviroment (A), the branch (27) debouching into the regeneration container (26) ensuring a continously working renewal of, at least, a portion of the solution circulating in the regeneration circuit (17).

20. A device according to claim 14 or 19, characterized in that the communication coil (25) between the containers (22, 26) is formed by a heat exchanger allowing a prefixed very modest liquid flow rate recirculated from the regeneration container (26) into the plenum one (22) to be always nearly in thermal equilibrium with the surrounding enviroment, for instance, a simple low diameter copper coil.

21. A device according to one or more of the preceding claims 15 to 20, characterized in that the sensor (37) sensible to the solution concentration consists at least in a liquid level sensor set inside the plenum container (22) or in a humidity sensor placed inside the plenum container (22) above the liquid phase or inside the segregated enviroment (A).

22. A device according to one or more of the preceding claims 15 to 21, characterized in that the plenum container (22) capacity and so the solution mass may be adjusted in order to control either the long period air humidity fluctuations as regard to average annual value also if disfunction of the regeneration system take place.

23. A device according to one or more of the preceding claims 15 to 22, characterized in that the controlling means consist of a controlling unit (35) having: a d.c. electric feeding unit of the Peltier element (34), a suitable electric feeding unit for the pumps (5, 5') and/or a fan (21), means to record a prefixed reference value of the solution concentration and means to compare the above mentioned signal with the one read by the concentration sensor (37), which means taking into account the observed difference between the said signals, select the polarity and supply the suitable prefixed voltage to the Peltier element (34) until a prefixed difference between the two signal exist.

24. A device according to claims one or more of the preceding claims 7 to 23, characterized in that the hygroscopic solution may be an acqueous solution of suitable substances, for instance glycerol, tryethylenglycol, or salt solutions such as LiCl, $MgCl_2$, $Ca(NO_3)_2$, or suitable mixtures between them.

25. A device according to one or more of the preceding claims 7 to 24, characterized in that the hygroscopic solution may hold small amounts of substances able to absorb and/or chemically neutralise, polluting substances which may be present inside the segregated enviroment (A).

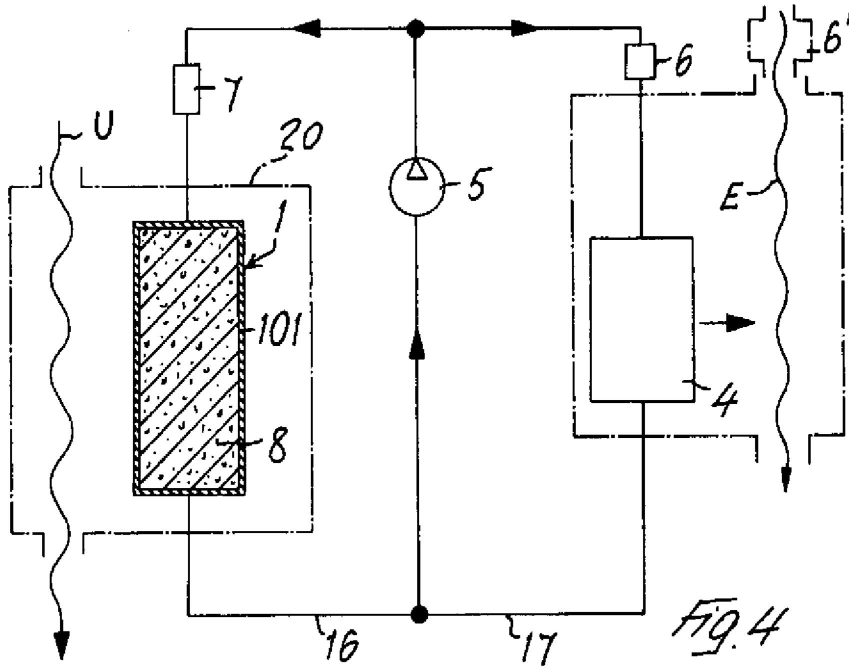

Fig.4

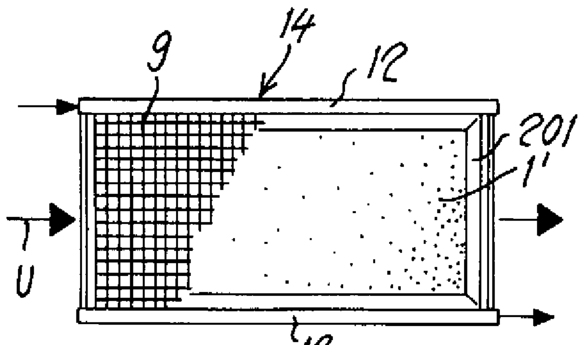

Fig.2

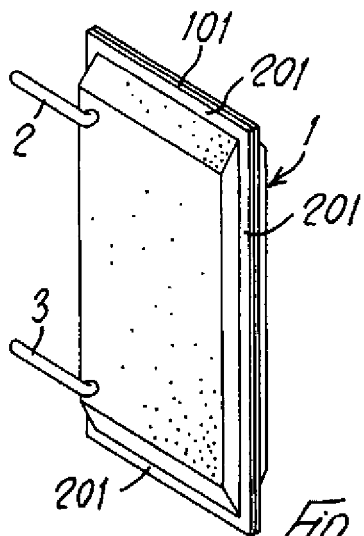

Fig.1

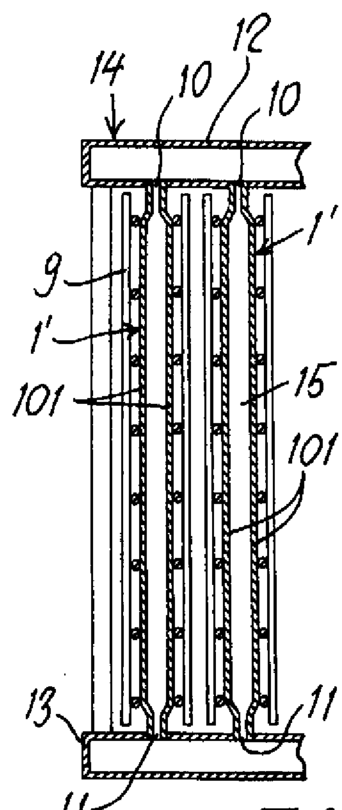

Fig.3

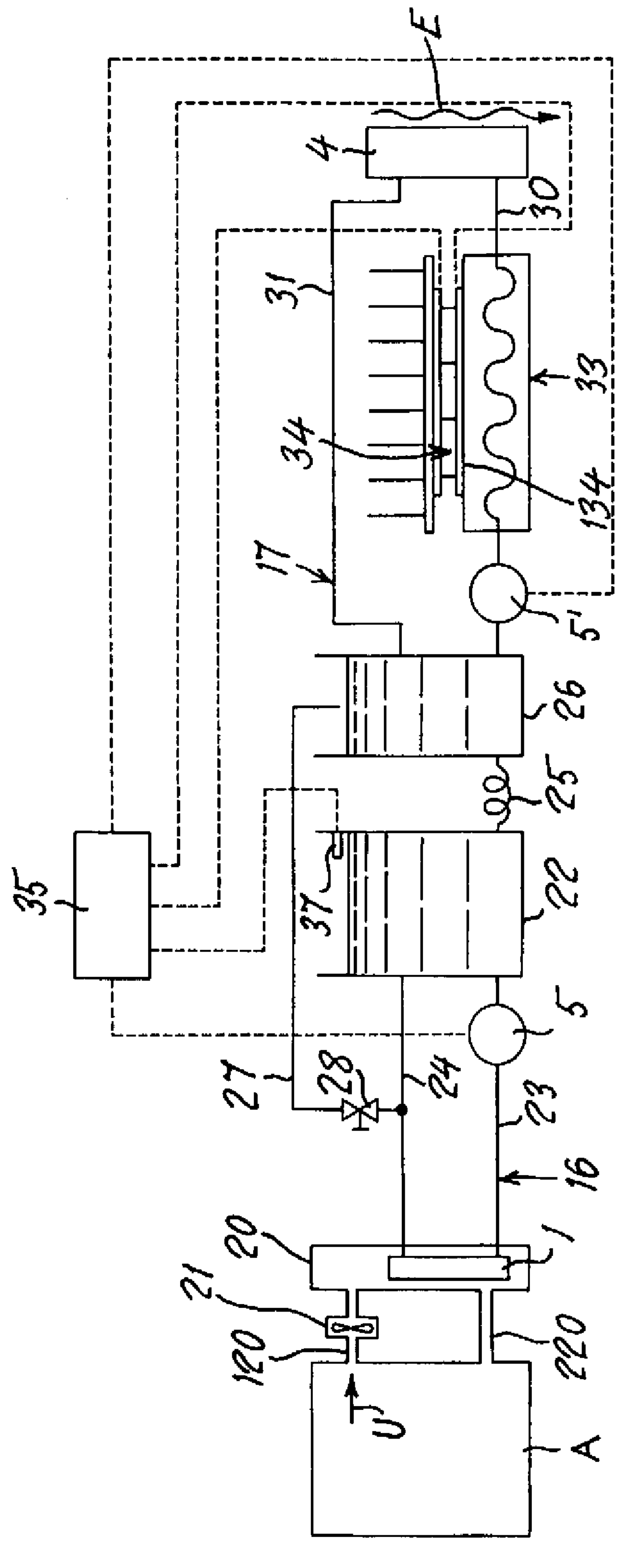
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Fig.5